FOOTWEAR SCIENCE
2025, VOL. 17, NO. S1, S233
https://doi.org/10.1080/19424280.2025.2493756

ABSTRACT

The impact of running shoe materials and structures on lower limb muscle activity in running sports: a systematic review

Xiangdong Wang[a], Kezhun Cao[a], Shutao Wei[b], Tao Liu[a]

[a]College of Physical Education, Jimei University, Xiamen, China; [b]361Â° China Co., Ltd., Xiamen, China

ARTICLE HISTORY Received 5 February 2025; Accepted 30 March 2025

KEYWORDS Running shoes; electromyography; lower limb biomechanics; midsole materials; footwear

Introduction

Running shoes are critical for optimising performance and reducing injury risks in runners. Over the past four decades of rapid evolution, many manufacturers of athletic footwear have sought to incorporate a range of functionalities into their prototypes, encompassing cushioning, stability, energy return, and motion control features (Li et al., 2009). Modern running shoes incorporate advanced materials [e.g., ethylene-vinyl acetate (EVA), thermoplastic polyurethane (TPU)] and structural innovations (e.g., carbon-fiber plates, dynamic arch systems) aimed at altering ground reaction forces (GRF) and neuromuscular responses. While prior reviews have focused on kinematic or kinetic outcomes, the relationship between shoe properties and lower limb muscle activity remains underexplored. Certain running shoe designs, while demonstrating advantages in kinematic and dynamic performance, may induce alterations in muscle activation patterns. This systematic review addresses this gap by evaluating how material properties and structural configurations influence electromyography muscle activation patterns during running, with implications for performance enhancement and injury prevention.

Purpose of the study

To characterise electromyographic activity of lower limb muscles during running under varied running shoes material and structural design conditions.

Methods

A systematic search was conducted across PubMed, Embase, SPORTDiscus, CINAHL, Scopus, Web of Science, Google Scholar (2010–2025) using keywords: running shoes, muscle activity, midsole materials, and biomechanics. Selected studies must specifically investigate electromyographic (EMG) characteristics of running mechanics under varied running shoe design conditions.

Results

Ten studies that met the inclusion criteria were included. (1) Material effects: Harder midsole materials led to a lower high-frequency EMG signal ratio. Heavier shoes led to significantly increased EMG signals in the gastrocnemius and semitendinosus muscles during the push-off phase, while lighter shoes increased tibialis anterior muscle signals during the pre-activation phase. Minimalist shoes increased EMG signals in the internal oblique and glutaeus maximus muscles. (2) Structural effects: The rocker shoes significantly reduced peak and duration of EMG signals in the glutaeal muscles during uphill running, while increasing muscle activation during flat running. The rocker-soled shoes significantly increased EMG signals in the vastus medialis and vastus lateralis muscles in most movements, while reducing signals in the biceps femoris and medial gastrocnemius muscles.

Discussion and conclusion

Running shoe materials and structures significantly influence lower limb muscle activity. Harder midsoles and rocker soles enhance running efficiency, while lighter shoes and minimalist designs improve stability and reduce injury risk. These insights guide shoe manufacturers in balancing performance and injury prevention. For runners, selecting shoes based on specific needs can optimise running economy and posture. Future research should explore long-term effects on muscle adaptation and injury incidence.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Reference

Li, J., Gu, Y., Lu, Y., & Wang, Y. (2009). Biomechanical study on the core technology of sports shoes. *China Sport Science*, *29*, 40–50.

CONTACT Xiangdong Wang wangxiangdong@jmu.edu.cn